SKA low band…
everything but Jamaican music

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Astrosiesta 19/01/2017

Square Kilometre Array

- *Led by the SKA Organisation (SKAO), not-for-profit UK company (2011)*
- *INAF in the Founding Board since the beginning*

The SKA Telescope

3 Telescopes (in phase 1)

- *SKA-low*
  - *131.072 dual polarized log periodic antennas*
  - *300 MHz bandwidth*
- *SKA-mid*
  - *192 dish antennas*
  - *5 GHz bandwidth*
- *SKA-survey*
  - *32 dish antennas, with PAF*
  - *500 MHz bandwidth*

SKA phase 2 (~ 2020)
~ 20x more antennas

SKA Phase 1 Implementation

Southern Africa

250 Dishes including
MeerKAT
SKA-Mid

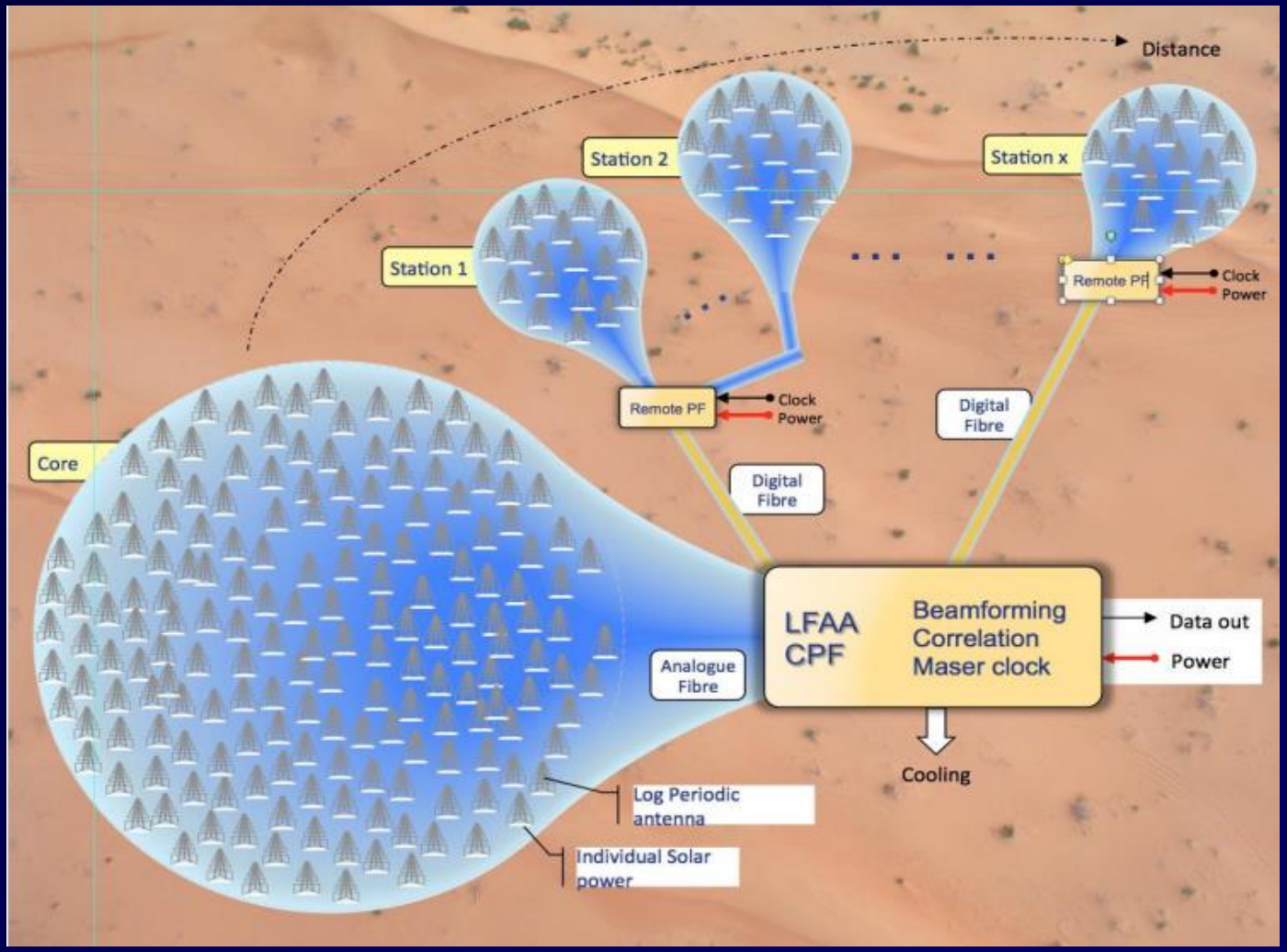
Australia

512 Stations (256 antennas each). Aperture Array Stations

90 Dishes including
ASKAP
SKA-Survey

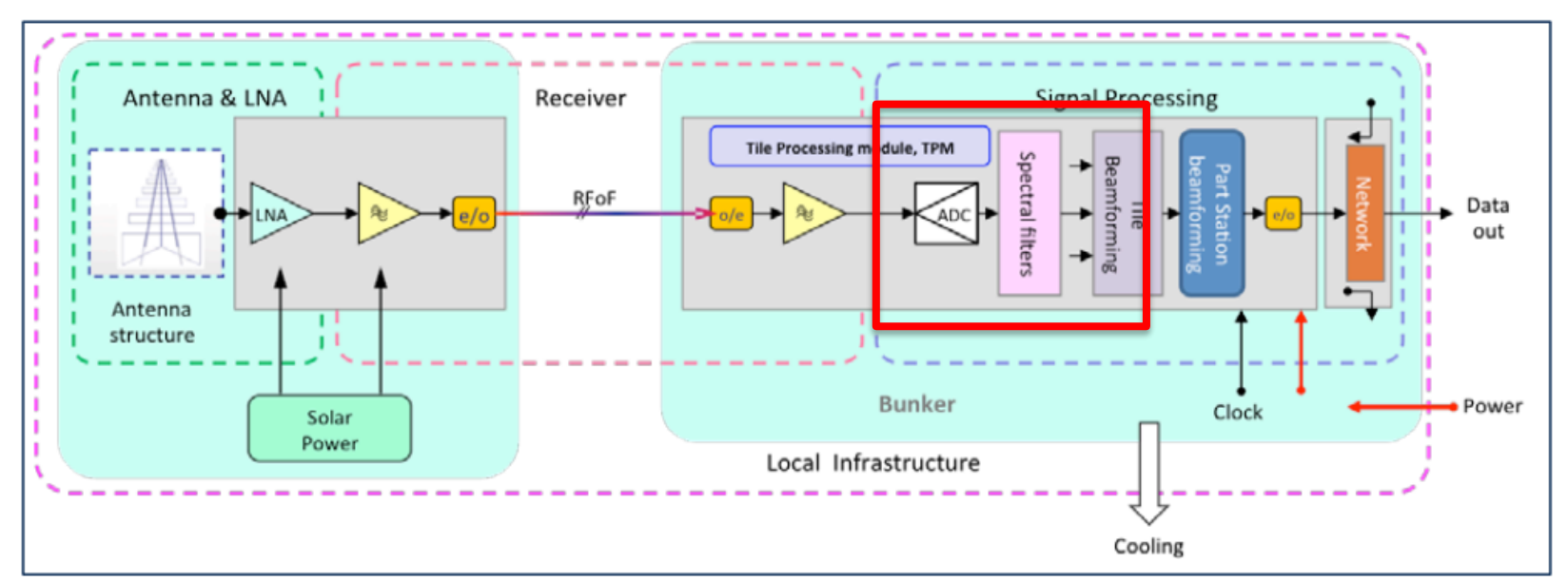
M. Alderighi, January 19, 2017

SKA-low Proposed Layout



LFAA Data Flow

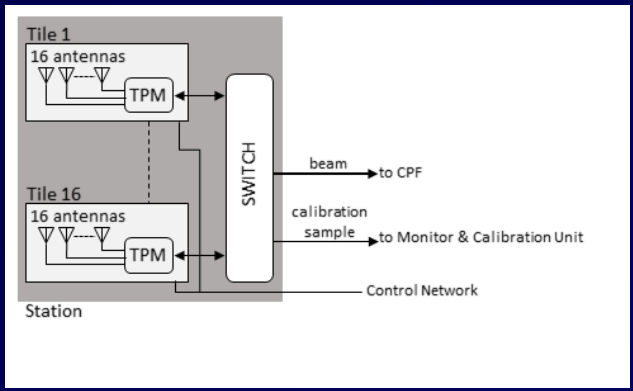
- *LFAA is an all-electronic telescope, based on stationary antennas with advanced signal processing and computing capability*

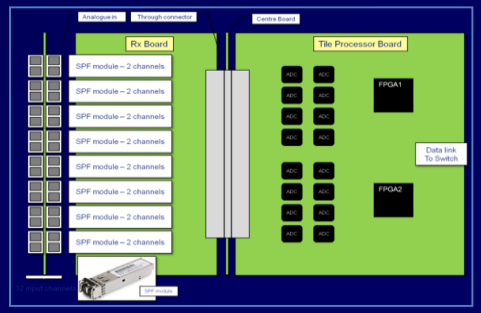


Tile: 16 Antennas, 2 Pol, 32 Channels
Station: 16 Tiles, 256 Antennas

ADU Operations

- Acquisition of 32 analog inputs corresponding to 16 double polarization antennas
- Analog to Digital conversion with sampling rate up to 1 GSPS
- Processing of acquired data, including channelization and beamforming
- Reception and transmission of data to other TPMs in the station through 40GbE links
- Forwarding of station beam to CPF through 40GbE links
- Collecting and transmission of data for calibration and monitoring purposes
- Low cost and low power modular solutions shall be considered → more than eight thousands boards for SKA1
- Existing hardware solutions for backends, UNIBORD and CASPER, turned out not appropriate

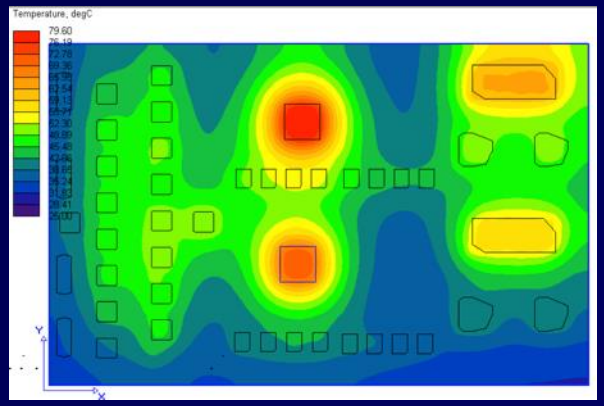


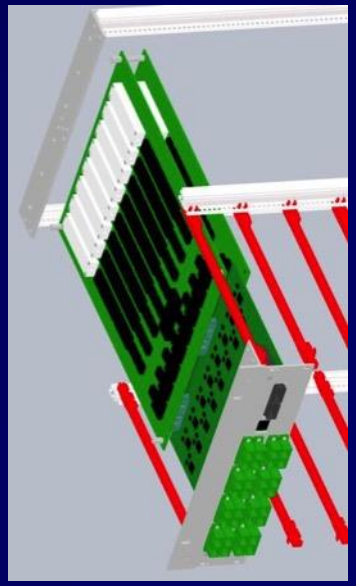


- AADC-TEL.LFAA.SE.MGT-AADC-PL-002, 2013
- Faulkner, A. & Bij de Vaate, J. G., IEEE Int'l Symp. on Phased Array System and Technology, 2013

Feasibility study

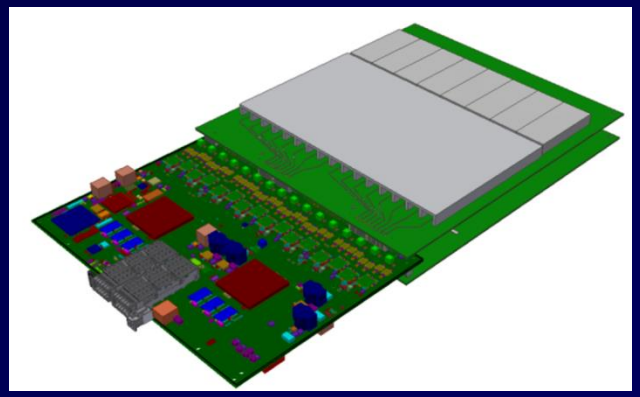
- Main device: FPGA & ADC
  - Xilinx Kintex UltraScale XCKU040
  - AD9680
- Rack assembly
- Board size & Power dissipation
- Board technology
  - PCB build-up
  - Isolation criteria
  - Sampling clock architecture
- Preliminary Board design



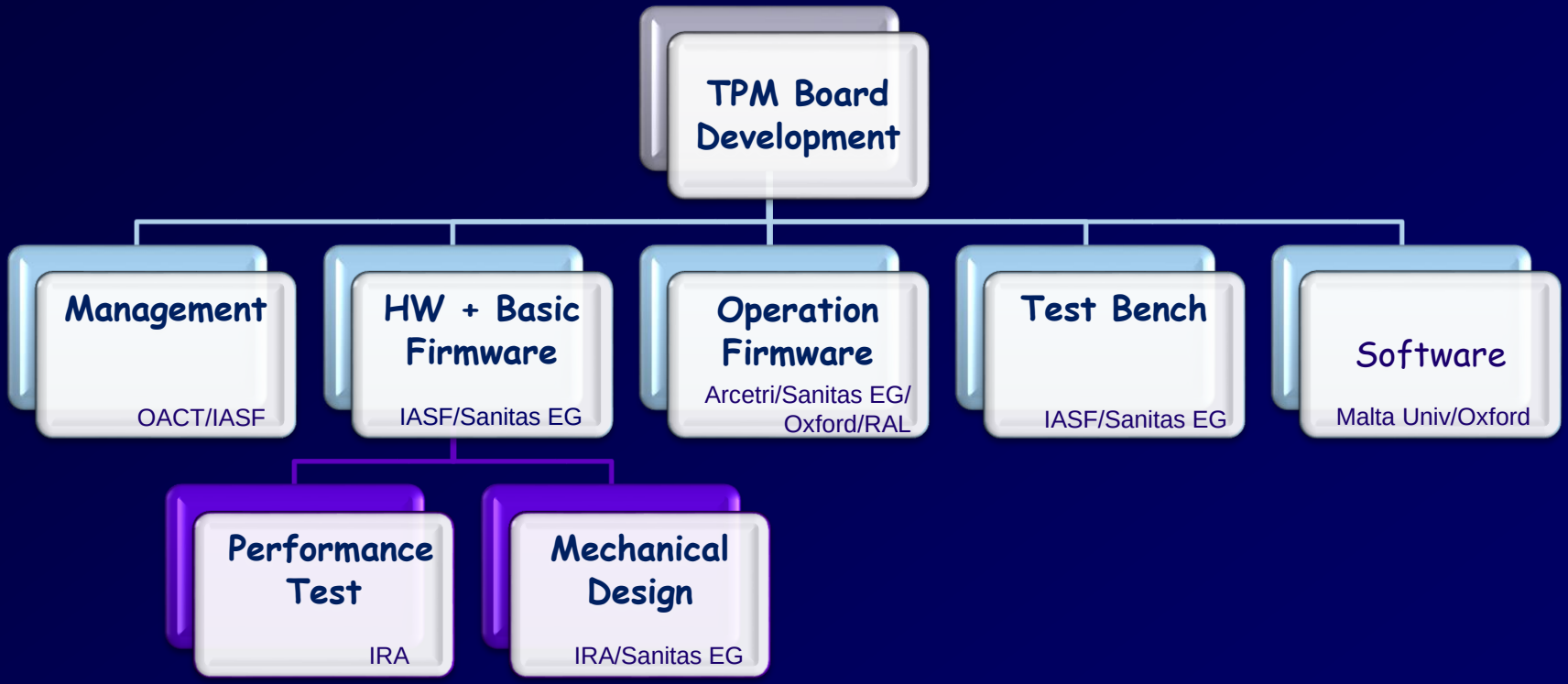


Tile Processing Module (TPM)

- TPM consists of two units
  - ADU board
  - Pre-ADU board: optical-electrical conversion, filtering, amplification and equalization of analog signals → manages 8 analog signals
  - TPM is an assembly of 1 ADU and 2 Pre-ADU boards
- First release of the assembly for the Aperture Array Verification System 1 (AAVS1) with the deployment of 400 antennas at the Murchison Radio-astronomy Observatory in 2017

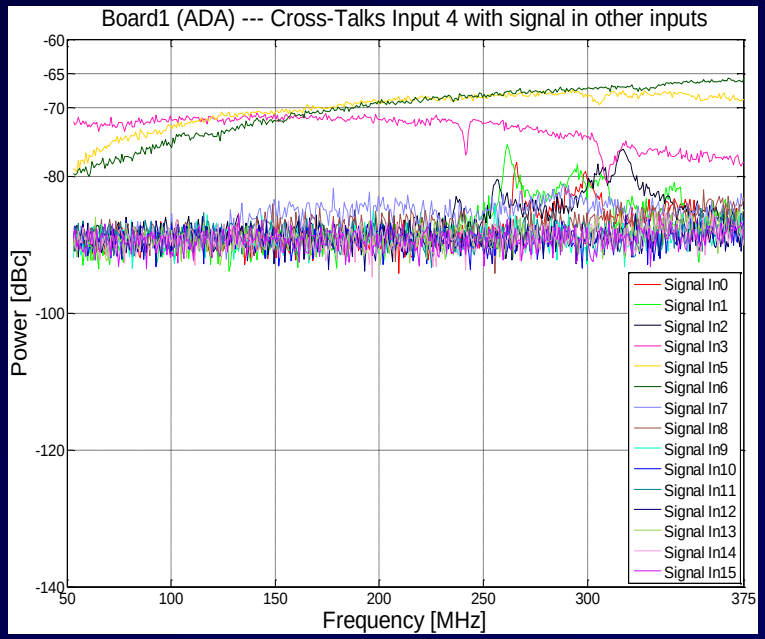


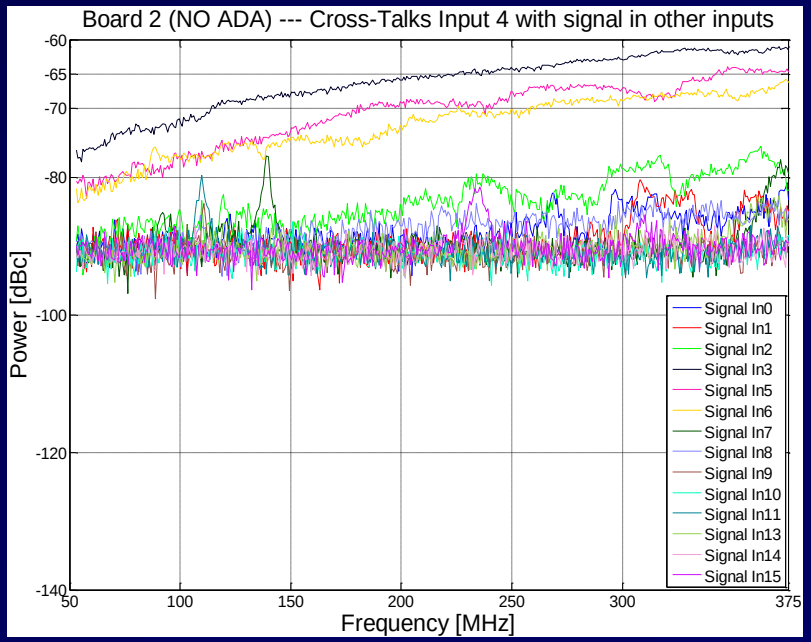
Activity Breakdown

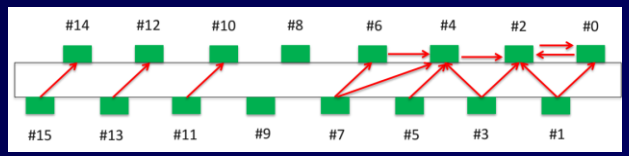


Cross-talk analysis

- Signal generator on each input, one at a time
- Off line FFT calculation on digitized sampled data
- Highest values in inputs #3, #5 and #6, very likely caused by the proximity of the traces in the PCB layout

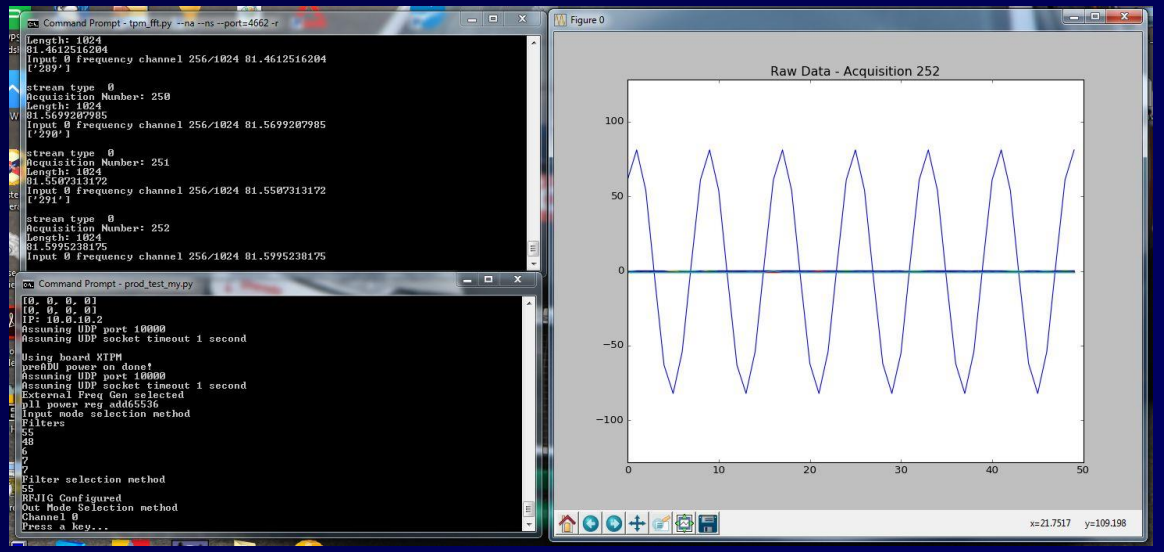


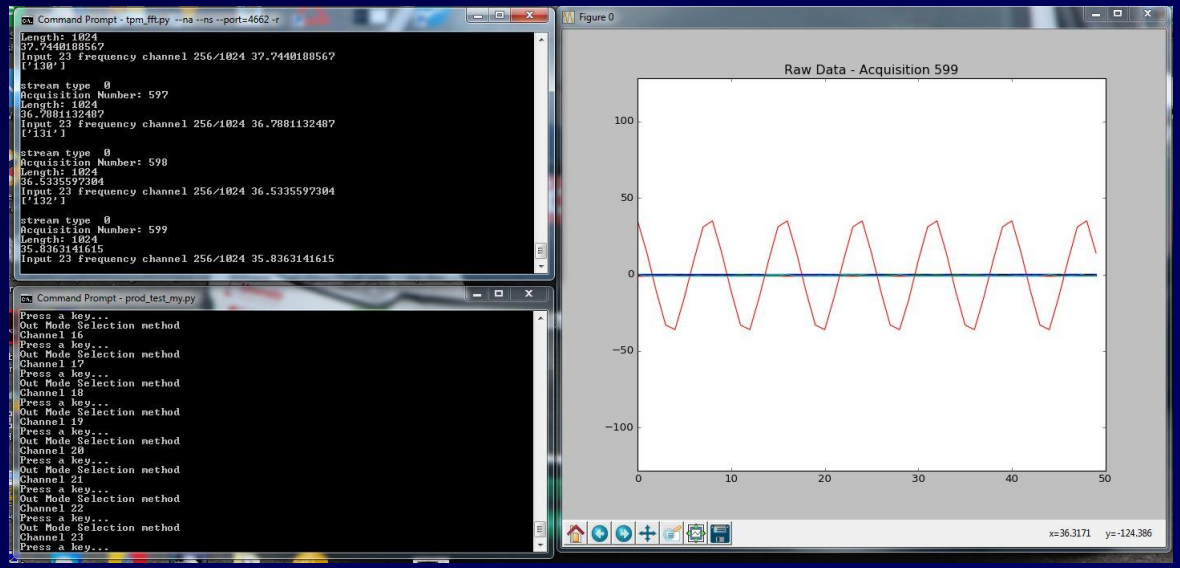




Digital signal quality

- *Signal generator onto a given channel through RFJIG*
- *The signal is acquired, digitized and stored in FPGA memory*
- *The signal is sent to the test PC via Ethernet link for off line analysis*





Performed activities

- Feasibility Study: January 2014
- Prototype production
  - R 1.0, 1 R.1, R 1.2
- Performance Tests
  - Data acquisition, configurations
  - Power consumption and temperature in rack
- Public Tender for AAVS1, 25 ADU boards
  - Published April 18, 2016
- ADU Testing
  - Test Specification
  - Test Firmware
  - Procedures for ADU board functional verification
  - Test JIG development

Future activities

- Deployment of 400 LFAA antennas at the Murchison Radio-astronomy Observatory
- ADU Upgrade
  - R 2.0 prototype featuring low power ADCs
  - High density rack capability
- Feasibility study for LFAA sub-racks with several TPM boards (#12)
- Design and implementation
  - Sub-rack
  - Sub-rack management board
  - Back plane board for sub-rack

www.skatelescope.org